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LANDSCAPE DIVERSITY OF MALA PLANINA

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The current paper represents an investigation of the landscape diversity of Mala Planina. The studied area is located in the western part of Bulgaria, in Western Stara Planina. It is surrounded to the north with the mountains of Chepun and Ponor, to the east with the mountains of Golema Planina and Sofyiska Planina and to the south by Sofia Valley. The present study is of a major importance because it is representing an investigation, concerning a mountainous area, situated in an immediate proximity to the capital city of the country, which is a prerequisite of major disturbances in the landscapes. Terrain and cameral methods are used for the investigation. The application of the software product of ArcGIS 10.1 is in the basis of the visual representation of the final product, which is the landscape map. It is built by combining layers of the rock foundation, relief, climate, soils and vegetation and other types of land cover. In the end, 103 different landscapes are distinguished, which represent the landscape diversity of the investigated area. It is dominated by landscapes with pastures and meadows and broadleaved forests, mainly located in the hypsometric band of 600-1000 m a. s. l.

Key words: landscape diversity, Mala Planina, ArcGIS, mapping.

INTRODUCTION

The geographic area of Mala Planina hides an unspoiled nature potential in its natural boundaries. The diverse natural complexes of the mountain are based on the interaction of lithology, relief, climate, water, soil, vegetation and fauna and together they are forming a rich landscape diversity. The interest towards Mala Planina raised, following the lack of landscape studies on this particular territory and its immediate proximity to the capital of

Bulgaria. The object of the investigation is of a representative character due its location, mountainous features and almost entirely rural settlement structure (with the exception of the towns of Svoge and Novi Iskar). According to Assenov (2011) along with the three known levels of diversity: genetic, species and ecosystem diversity, a fourth level should be introduced. This is the landscape diversity, following the "specific interactions among biotic and abiotic components of the landscape sphere" that are in the basis of it and the geographic area of Mala Planina allows for an investigation of the landscape diversity. The authors also add a syntaxonomic level, which is of a major importance for the landscape level.

The main aim of the study is the investigation of the landscape diversity in Mala Planina, based on the functioning of the landscapes, as an indicator for sustainable development. Several goals were accomplished for the purposes of the current paper: an analysis of the historical development of the natural components of Mala Planina; a differentiation and classification of the contemporary landscapes; mapping of the landscapes and development of a map of the landscape diversity.

Previous landscape studies play a central role in the current investigation. Important summarizing works are "Landscape Geography of Bulgaria" (Velchev et al., 2011) and "40 Years of Department Landscape Sciences and Environmental Protection" (2013). Several decades before these works, Petrov (1974) completed the first complex physicogeographical zonation of Bulgaria, based on the landscape typological fundament. A few years later again Petrov (1980) developed a classification system of the Bulgarian landscapes and created a map in M 1:400 000. In 1989 Petrov, Popov and Baltakov presented a new classification system, entitled "Basic geoecological classification of landscapes on Bulgaria", but it lacks a legend and a landscape map. As a continuation of this work Popov (2001) developed a taxonomic system, including 8 taxa and subtaxa, differentiated on morpholitogenic, hydro-climatic, soil-biogenic and anthropogenic factors. Back in 1989 a landscape map in M 1:500 000 was presented by Velchev, Todorov and Beruchashvili, with the participation of Assenov (1992), at the geographic congress in Veliko Tarnovo. A series of landscape research was conducted in Western Stara Planina by Konteva (1992 a,b,c), which help for clarification of the landscape specifics of Mala Planina. In 2014 Todorov published a summarizing work along with prof. Angel Velchev, entitled "Landscapes of Bulgaria – Spatial Structure". The dissertation of Cholakova (2016) is also important for the investigation of the landscapes in Mala Planina. Nedkov (2008, 2011) worked on mapping and investigation of landscape data, and Zhelezov (2011) published a study, based on modelling and analysis of chosen landscapes in mountainous areas in the country.

METHODOLOGY

A former study of the landscapes in a part of Mala Planina was carried by Grigorov et al. (2015) and the current investigation has an indivisible connection with it. In the first investigation of the landscapes of the mountain, the exact boundaries weren't specified completely, so the area was locked by the valley of the Iskretska River to the north, the Iskar River to the east, the rivers Kriva and Dalbochitsa to the south and the road of Lomsko shose to the west. After continuous investigations, a revision of the boundaries of the mountain and with the

indispensable help of the article by Velchev & Zaharieva (2016), where Kamuka Ridge is defined as a part of Mala Planina, a review of this landscape study was needed. Henceforth, to the north of Mala Planina are the mountains of Ponor and Chepun, to the south is Sofia Valley and to the east are the mountains of Golema Planina and Sofyiska Planina.

The application of the system's approach is essential for the current landscape investigation. Solving ecosystem problems is the essence of the ecosystem approach and the main idea is the sustainable management and protection of the environments by the application of scientific arguments and methods. These methods are pointed towards different biological levels of organization, encompassing the processes, functions and interactions between the organisms and the environment in which humans are becoming more and more integral part. At the same time, in the landscape approach the environment and the human systems, that are depending on it, are considered.

Terrain expeditions and observations are in the basis for the current study (Table 1). A series of mappings of different parts of the mountain were carried out and lots of samples were acquired. Three main stages were accomplished in order to fulfill the main aim: collection and processing of primary data, terrain research and final processing. A survey, based on literature and cartographic sources of information and satellite images, was conducted in order to gather enough primary data for the development of the landscape map. Terrain expeditions included recognition, marking of typical features, choosing key sections and mapping. In the end the collected information was processed, systematized and analyzed for the creation of the landscape map of Mala Planina. During the process of preparation, contemporary landscape investigations of areas in Bulgaria, were studied. Chronologically, they include "Landscape Map of Bulgaria in M 1:500 000" (Velchev et al., 1992), "Landscape Structure" (Petrov, 1997) and "Geoecological Classification of the Landscapes in Bulgaria" (Popov, 2001).

The hierarchical and the genetic approaches are applied as a basis for the development of the classification of the landscapes in Mala Planina. These approaches are tied to the consistency of the landscapes and the compliance with the continuity of their differentiation, as well as the fact that the factors for landscape formation are central for the investigation. The principles of complexity, relative homogeneity, logical correctness and practical application are taken into account. The development of the landscape map of Mala Planina is based on the georeferenced system of the European landscapes by The European Landscape Character Initiative (ECLAI) including the European Landscape Map (LANMAP 2). The system is developed under European project (Wascher, 2005) and it is a product of the work of many scientists who regard the evaluation of landscapes as a central moment for the sustainable

Table 1

Studying activities in Mala Planina for the period 2014–2017

GPS points (number)	Landscape plots (number)	Soil analyses (number of samles)
		organic carbon
48	39	9

development concept. The landscape map is a result of a combination of layers in GIS environment by the application of the ArcGIS 10.1 software. The layers consist of georeferenced data about geology (a map with M 1:100 000), relief (topographic map with M 1:25 000; M 1:50 000), climate (by the application of the Thornthwaite index), soils (created by JICA, M 1:400 000) and vegetation and other types of land cover. Here is the right place to point some criticism of LANMAP 2, presented by Konteva (2016), stressing on the fact that the system is used primarily for documentation of landscapes, rather than for providing quality assessment. Nevertheless, it is regarded by the authors of the current study as good enough to comply with the goals of the investigation. According to LANMAP 2, four different layers are combined in one: climate, topography, parent material, land cover (Fritz et al., 2003; Mücher et al., 2010). The current study uses this approach, however, the applied criteria are different in some way. This is not the first study in Bulgaria, which uses LANMAP 2 for the mapping of landscapes. Borissova & Kotsev (2012), Borissova & Tsambova (2012) and Borissova et al. (2014) successfully conducted investigations in Strandzha, Central Stara Planina and the Rhodopes, which is a prove for the correct and successful application of LANMAP 2 in investigating landscapes in mountainous areas. Borissova & Kotsev (2012) use a new methodological approach for an interpretation of information in GIS environment by the application of the natural boundaries in drainage basins and extend the information basis for diagnostic criteria. The cited landscape studies in Bulgaria are completed by the principle of "uniform spatial dimensionality" of the classification categories, which is justified in the geoecological classification of Popov (2001).

RESULTS AND DISCUSSION

The clarification of the current condition of the landscapes in Mala Planina is in full concordance with the goals in European Landscape Convention (http://www.coe.int/en/web/landscape), according to which countries have to classify, analyze, protect and plan their landscapes. A landscape classification is created in order to fully differentiate the landscape diversity of the mountain (Table 2).

The highest taxonomic unit is the Class and it is based on the specifics of macromorphology. According to them, the studied object falls within one class – the mountainous landscapes, marked with the symbol „P". Hydro-climatic conditions are the main diagnostic criterion for distinguishing the second level – Type. The classification of the climatic types, according to the Thorntwaite index, is applied here and based on it Mala Planina has two types of landscapes: with humid climate (H) and with wet subhumid climate (W). The diagnostic criterion for the Subtype is the zonal vegetation (V). The Genus – Level 4, is based on the type of process of relief formation. There are several major processes, leading to the formation of denudation levels without karst (I), denudation levels with karst (II) and erosional and denudation landscapes (III). The next taxonomic level is the Group and it is based on the rock fundament as a factor for landscape differentiation. There are four groups of landscapes in Mala Planina: with carbonate sedimentary rocks (c), non-carbonate sedimentary rocks (n), magmatic and metamorphic rocks (m) and uncosolidated deposits (u). The edaphic factor is the most essential factor for the differentiation of the taxonomic level 6 or the Type. There

Table 2

Factors and Criteria for Landscape Classification and Differentiation

Classification Category/Level of Differentiation	Diagnostic Criteria	Level of Generalization	Symbol
Class (Level 1)	macromorphology	mountainous Landscapes	P
Type (Level 2)	hydro-climatic Conditions	humid Climate	H
		wet Subhumid Climate	W
Subtype (Level 3)	zonal and intrazonal vegetation with communities of classes: *Carpino-Fagetea sylvaticae*, *Quercetea pubescentis, Robinietea*, *Crataego-Prunetea, Molinio-Arrhenatheretea*, *Festuco-Brometea*		V
Genus (Level 4)	mezorelief (including the character of current processes for the formation of the relief)	denudation level without karst	I
		denudation level with karst	II
		erosional and Denudation levels	III
Group (Level 5)	rock fundament	carbonate sedimentary rocks	c
		non-carbonate sedimentary rocks	n
		magmatic and metamorphic rocks	m
		unconsolidated deposits	u
Type (Level 6)	soil type	*eutric Fluvisols, FBe*	1
		dystric u gleyic Colluvisols, CLd u CLg	2
		chromic Luvisols, LVx	3
		eutric Vertisols, VRe	4
		eutric Cambisols, CMe	5
		rendzic Leptosols, LPk	6
		albic Luvisols, LVa	7
Subtype (Level 7)	vegetation/land cover	artificial birch forests (*Betula pendula* Roth) at the place of oak forests (*Quercus sp*.) and beech forests (*Fagus sylvatica* L.)	bp
		communities of the *Fagetalia sylvaticae*, alliance *Fagion sylvaticae*	fs
		communities of the alliances *Quercion petraeo-cerridis* and *Carpinion betuli*	cbqd
		communities of the alliances *Quercion petraeo-cerridis* and *Carpinion orientalis*	coqp
		coniferous forests (*Pinus sylvestris* L.*; Pinus nigra* Arnold*; Picea abies* (L.) Karst.*; Pseudotsuga menziesii ssp menziesii*)	pin
		communities of the alliance *Quercion confertae*.	qcqf
		deciduous forest with non-native species (*Quercus rubra* L.*; Robinia pseudoacacia* L.)	inv
		communities of the alliance *Berberidion vulgaris*	cmps
		pastures and Meadows of the classes *Molino-Arrhenatheretea* and *Festuco-Brometea*	pame
		quarry	quar
		anthropogenic territories	antr
		agricultural areas	agri

are seven varieties of landscapes in Mala Planina for level 6: with *eutric Fluvisols, FBe*, (1), *dystric* and *gleyic Colluvisols, CLd* and *CLg*, (2), *chromic Luvisols, LVx*, (3), *eutric Vertisols, VRe*, (4), *eutric Cambisols, CMe*, (5), *rendzic Leptosols*, *LPk*, (6) and *albic Luvisols, LVa*, (7). The last level for landscape differentiation and classification of Mala Planina is the seventh, which represents the Subtype. It is based on the vegetation and other types of land cover. Woodland, shrubland and grassland vegetation subtypes are united in order to get a clearer marker for the landscapes. All subtypes are indicated in Table 2.

The software product ArcGIS 10.1 is used for the spatial landscape analysis and mapping of the territory of Mala Planina and an analytical database is modelled. In order to fully characterize the area, different vector layers are applied. These layers consist of georeferenced database about geology, relief, climate, soils, vegetation and other types of land cover.

LITHOLOGY

The georeferenced lithological layer (Fig. 1) is based on a geologic map of the area in M 1:100 000, providing information for a very rich lithological diversity. The different types of rocks are united in four groups, based on their chemical composition and formation, in order to avoid unnecessary detail:

1. Carbonate sedimentary rocks – clayey, sandy, organogenic, dolomitic limestones; dolomites; alevritic marlstones.

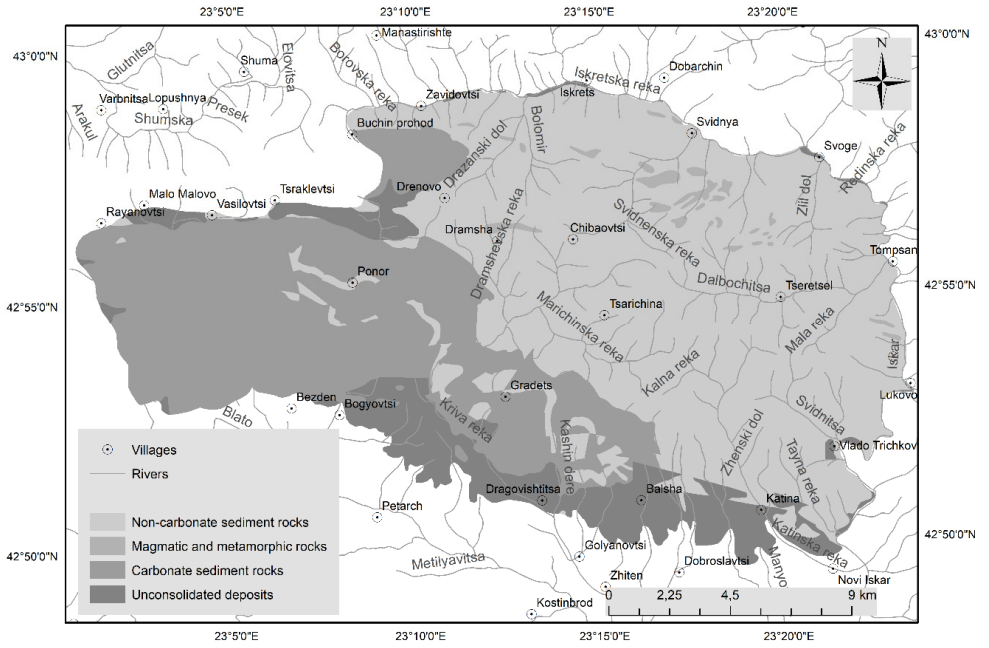

Fig. 1. A map of the lithology of Mala Planina

2. Non-carbonate sedimentary rocks – sandstones, argillites, siltstones, conglomerates, breccias.

3. Unconsolidated deposits – clays, sands, gravel.

4. Magmatic and metamorphic rocks – dacite, porphyry, syenite, shonkinite, quartzite, andesites and trachyandesites – tuffs.

Landscapes with non-carbonate sedimentary rocks are covering 56% of the total area, followed by landscapes with carbonate sedimentary rocks (31%), located mainly in the western part of Mala Planina – in the Kamuka Ridge. Landscapes with unconsolidated deposits (11%) are situated in the southern parts of the mountain, while landscapes with magmatic and metamorphic rocks, accounting for only 2% of the studied object, are located to the northeast, forming a mosaic.

RELIEF

A database, involving contemporary relief forming processes, is used for the creation of the vector topographic layer. The layer is based on the morphometric parameters of ASTER GDEM and the use of a topographic map with M 1:25 000. The studied object is divided into landscapes with karst, landscapes without karst and erosional and denudation landscapes (Fig. 2). The largest proportion of the territory (around 50%) is taken up by the erosional and

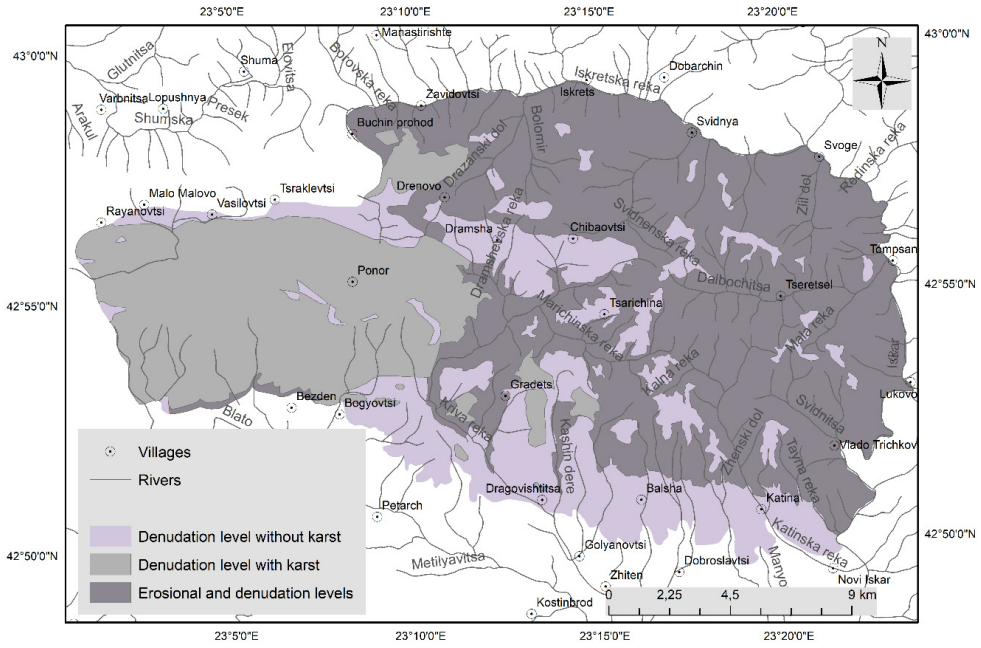

Fig. 2. A map of the relief of Mala Planina

denudation landscapes. They dominate in the eastern part of the mountain, while they are almost missing in the Kamuka Ridge, where only a small band is presented in its southern part. Landscapes with denudation levels with karst (around 25%) are situated exclusively in Kamuka Ridge, while landscapes with denudation levels without karst (about 25%) are located mainly in the southern and central parts of Mala Planina.

CLIMATE

The humidity index of Thorntwaite is applied for the classification of climatic types in Mala Planina. Borissova et al. (2015) consider it to be highly informative for the systematization of landscapes on humidity or aridity basis, as well as for the type of potential vegetation and the exchange of energy and matter. The results of the studies of Topliisky (2006) (including cartographic material) are taken under consideration and the landscapes of Mala Planina are divided into humid and wet subhumid (Fig. 3). Humid landscapes account for 85% of the

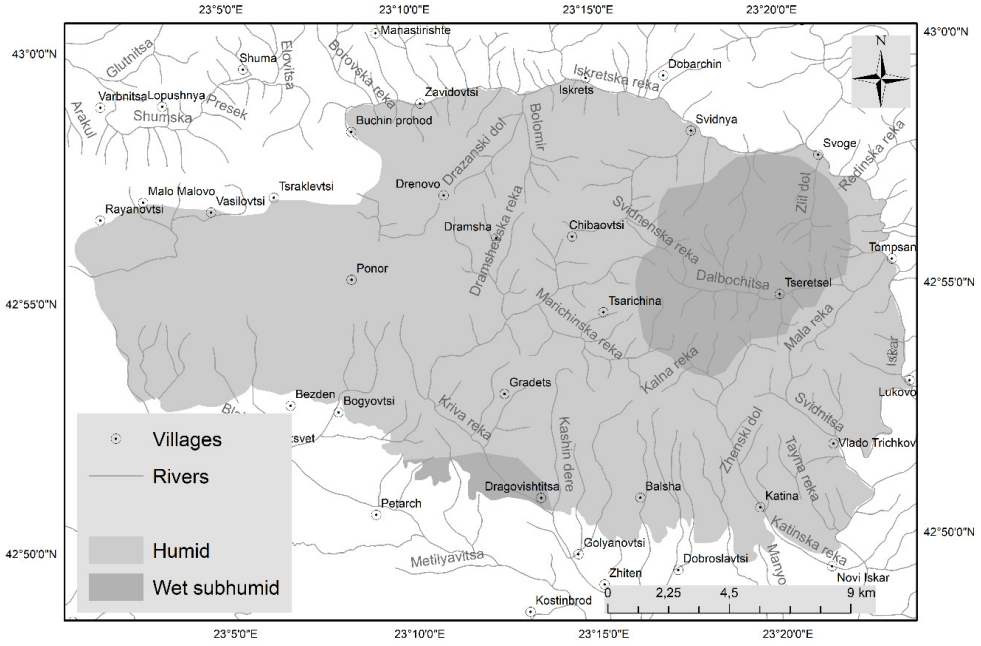

Fig. 3. A climatic map of Mala Planina

territory of the mountain, while the rest 15% are allocated to the wet subhumid landscapes, situated near the highest parts of the territory to the northeast.

SOILS

The edaphic factor is also very important for the landscape formation and a soil map of Bulgaria (M 1:400 000) is used for the definition of the landscapes of Mala Planina. *Eutric Cambisols, Cme*, are located in the northern parts of the mountain and they comprise around 12% of the studied area. *Rendzic Leptosols, LPk*, are situated in the karst areas to the west and landscapes with this soil cover over 32% of the territory. *Dystric* and *gleyic Colluvisols*, *CLd and CLg*, (under 1%) and *Eutric Fluvisols, Fbe* – 3% have mosaic localities in the southern periphery, while the subtypes of the *Chromic Luvisols, LVx*, (14%) and *albic Luvisols, LVa*, (32%) are situated in the central and southern areas, accordingly. Landscapes with *Eutric Vertisols, Vre*, cover around 7% and they are situated mainly in the western part of Kamuka Ridge (Fig. 4).

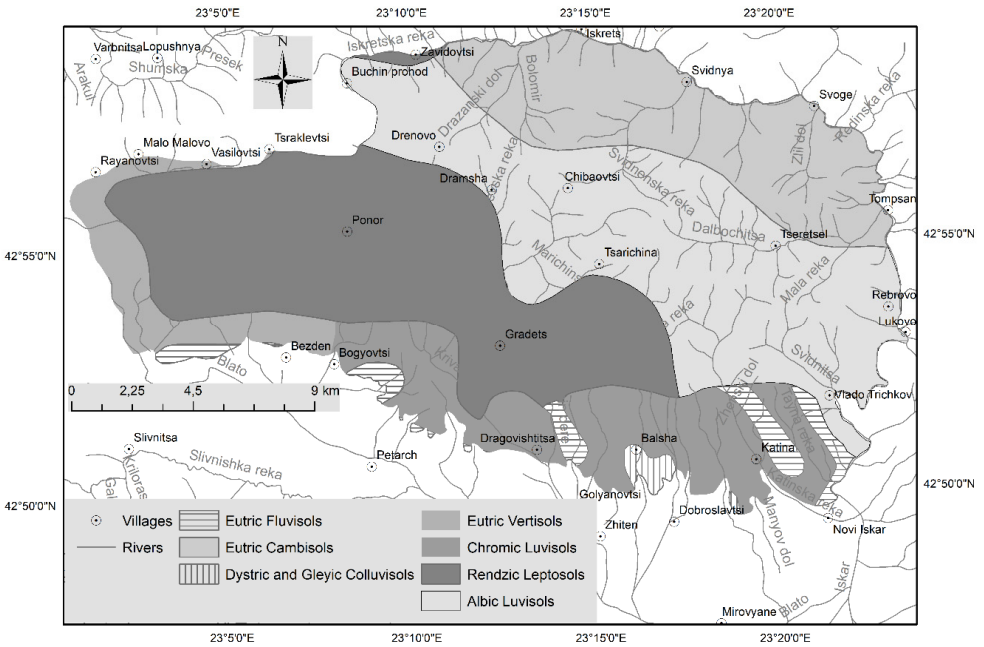

Fig. 4. Soil map of Mala Planina

VEGETATION AND OTHER TYPES OF LAND COVER

The current layer is obtained with the kind cooperation of the Forestries of Sofia and Svoge. It is generalized for the purposes of the current investigation and consists of data about woodland and shrubland species, as well as data, concerning the presence of pastures and meadows, while at the same time it also presents areas with agriculture and anthropo-

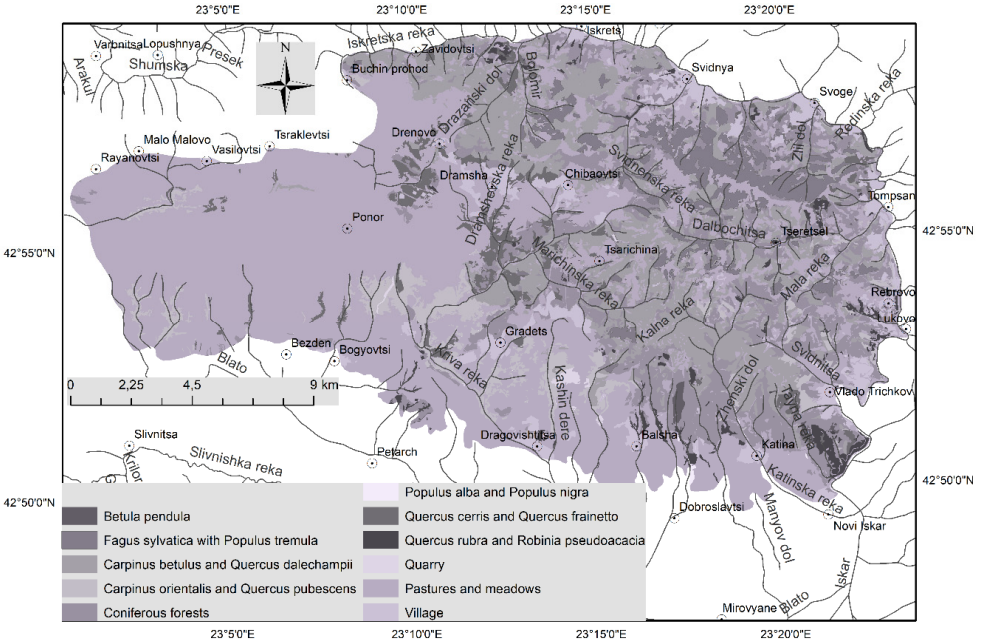

Fig. 5. Vegetation and other types of land cover of Mala Planina

genic territories (Fig. 5). Landscapes with pastures and meadows are located mainly in the western part of the mountain and they cover around 34% of Mala Planina. Forests, dominated by *Carpinus betulus* L. and *Quercus dalechampii* Ten. cover 23% and are situated in the northern and central part of the territory. Landscapes with coniferous forests (*Pinus sylvestris* L.*, Pinus nigra* Arnold*, Picea abies* (L.) Karst.*, Pseudotsuga menziesii ssp menziesii*) come to the third place and cover around 14% of Mala Planina. These forests are artificial are situated mainly in the eastern and southern parts of the studied area. Each one of the landscapes with forests, dominated by *Fagus sylvatica* L., forests with *Carpinus orientalis* Mill. and *Quercus pubescens* Willd. and landscapes with agriculture cover around 6% of Mala Planina. Beech forests are located in the higher hypsometric parts of the mountain to the northeast, while territories with agriculture are situated at the transition area to Sofia Valley to the south and near the villages of Golemo Malovo and Malo Malovo to the northwest.

All layers of the landscape components, that were discussed in the previous lines, are processed by the ArcGIS tool for "Generalization" – "Dissolve" and later are combined in one final layer with the tool for "Overlay" analysis "Intersect". The inevitable formation of landscape polygons with too small area lead to the use of the tool "Eliminate". With its help the minimum area of a mapped polygon is 20 ha. This action was necessary for receiving a higher application value of the map and also a better level of readability. The correct representation of the geographic nomenclature was accomplished by the use of the layers, created by the Japan International Cooperation Agency (JICA).

Every element of the vector layers is represented by a code symbol (see the last column of Table 2). All symbols are displayed in the map legend and they present the landscape diversity of Mala Planina (Fig. 6). The identification of the landscapes was made possible by the application of a code, which is a combination of the symbols, representing all factors for landscape formation. In order to avoid the unnecessary elongation of the codes in the legend, the symbols „P" и "V", representing Class (Level 1) and Subtype (Level 3) are omitted, because they are the same for all landscapes in Mala Planina. An example of a code combination, representing a random landscape, is the following: a landscape with humid climate, on a denudation level with karst with carbonate sediment rocks, *rendzic Leptosols, LPk*, and pastures and meadows is represented by the code Hc6Iipame. The same logic is followed when it comes to every landscape in the mountain. A total number of 103 landscapes are differentiated in Mala Planina, logically divided, following the quantitative characteristics of the natural components.

The presented landscape map of the studied object (Fig. 6) displays the abundance of landscapes in Mala Planina. The largest share (87%) belongs to those landscapes that are located in the hypsometric belt between 600 and 1000 m a. s. l., which is logical due to the specific geographic characteristics of the investigated area. Landscapes between 1000 and 1234 m a. s. l. account of 8% of the territory and come to the second place. They are located in the northeastern parts of the mountain near the highest peak – Tseria (1234.1 m a. s. l.).

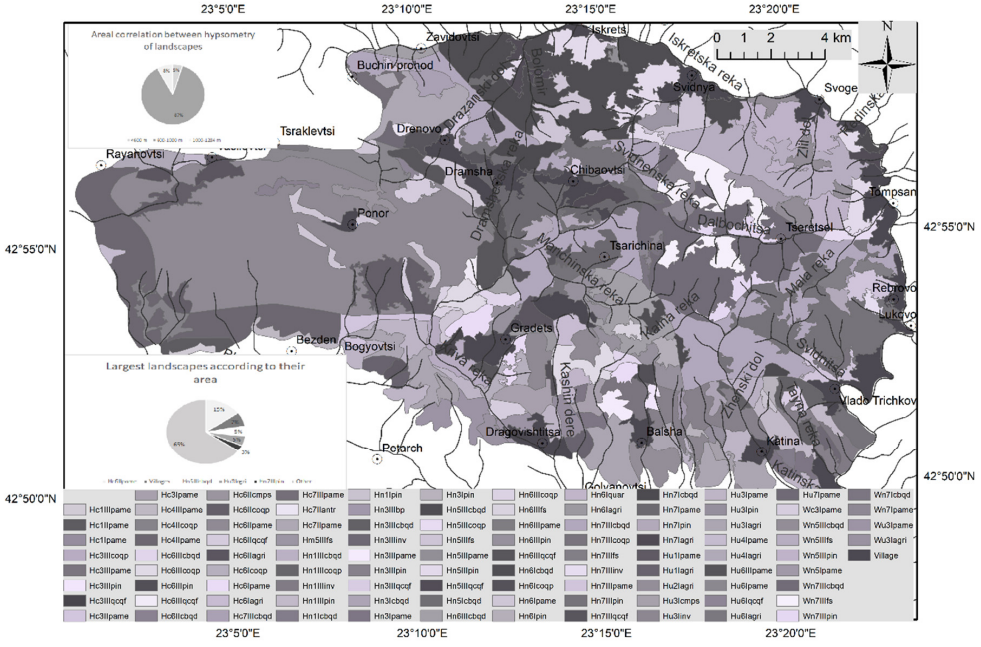

Fig. 6. Landscape map of Mala Planina

Landscapes that are situated under 600 m a. s. l. cover 5% of the studied area and they can be found near the rivers of Iskretska and Iskar where are the lowest parts of Mala Planina.

The landscape differentiation, according to the area, has some specific features: landscapes with the largest area are those with pastures and meadows, carbonate sediment rocks, denudation levels with karst, humid climate and *rendzic Leptosols, LPk*. They are located in the western part of the Kamuka Ridge and account for 15% of Mala Planina. Erosional and denudation landscapes with *Carpinus betulus and Quarcus dalechampii* on non-carbonate sediment rocks with humid climate and *albic Luvisols, Lva*, cover 8% of the mountain. They are located mainly in the northeastern parts. Villages in Mala Planina take up to 7% of the total area and the largest of them are situated along the banks of the rivers Iskretska and Iskar. Erosional and denudation humid landscapes with *Carpinus betulus and Quarcus dalechampii* on *eutric Cambisols, CMe*, cover 5% of the territory and they are located in a fragmented manner in the eastern part of the mountain. Landscapes with pastures and meadows, humid climate and denudation levels with karst, located in the Kamuka Ridge take up to 4% of the total area. Some of the rest of the landscapes in subtype level have a certain level of fragmentation and their areas are following the laws of geography and the influence of the factors for landscape formation.

CONCLUSIONS

The application of the current methodology proved to be successful for a landscape investigation of a mountainous area in the western part of the country. By using georeferenced layers in a GIS environment and the application of the approach, used in LANMAP 2, a full map of the landscape differentiation of Mala Planina was created. The layers, consisting of information about geology, relief, climate, soils, vegetation and other types of land cover and the combinations of them, lead to the differentiation of a total number of one class, two types, one subtype, three genuses, four groups, seven types and twelve subtypes. They lead to the formation of 103 different landscapes on the territory of Mala Planina. The landscape map of the area displays a vast diversity of landscapes. 87% of them are in the hypsometric belt between 600 and 1000 m a. s. l. and they represent the largest share. If landscape differentiation is taken into account, the largest proportion of the landscapes belongs to the pastures and meadows on carbonate sediment rocks, denudation levels with karst, humid climate and *rendzic Leptosols, LPk*, located in the western part of Mala Planina – the Kamuka Ridge, covering 15% of the territory.

The created landscape map of Mala Planina allows for a full analysis of the landscape diversity as the most comprehensive system of biodiversity in the direct application in landscape planning. The authors of the presented study are convinced that it can be used as a basis for other investigations with similar aims, as well as a fundament for a much broader and extensive study of the landscapes, situated in the western part of Stara Planina.

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